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ARIZONA INTELLIGENT VEHICLE PROGRAM – PHASE TWO(b): 2001-2002

This report summarizes Phase Two(b) of a long-term Intelligent Transportation Systems (ITS) research program by the Arizona Department of Transportation (ADOT) to study infrastructure-based cooperative guidance technologies and vehicle systems. The project is an in-house effort of ADOT's Arizona Transportation Research Center (ATRC) in Phoenix.

Introduction

Phase Two(b) of Arizona's advanced-vehicle research was the 2001-02 winter, Year Four of the program. During this phase, the ADOT-ATRC research team conducted side-by-side evaluations of two infrastructure-based vehicle lane guidance systems. The 3M Company had already commercially developed one of these guidance systems, and the other was being developed through a program sponsored and led by the California Department of Transportation (Caltrans).

Background To Phase Two(b)

Phase One of the ADOT Intelligent Vehicle Research Program (1997-2000) began with Arizona demonstrations of Intelligent Vehicle (IV) and Automated Highway System (AHS) concepts. It soon became clear to ADOT that the most practical near-term application of IV technology for a state highway agency would be in the challenging field of winter maintenance

operations, and this project evolved toward the "specialty vehicles" research arena.

Phase One was a joint partnership with Caltrans to field test its prototype Advanced Snowplow (ASP-I and later ASP-II) in Arizona. Relieved from developing an advanced research snowplow on their own, the ATRC's research team instead concentrated on constructing a six-mile magnet test loop at Kendrick Park on US 180 northwest of Flagstaff. The Arizona test site enabled Caltrans to diversify its ASP research experience with tests in different conditions and with a second, discrete pool of plow operators. During the two winters of the Phase One research program, the ADOT snowplow crews were trained on and evaluated the prototype Caltrans lane-guidance system in month-long test cycles.

In Phase Two (2000-01) of the project, the ADOT project team set a new key goal. The Caltrans ASP, now evolved to the RoadViewTM advanced snowplow, was available to Arizona for only a few weeks each winter. This was not sufficient for a thorough evaluation of the ASP system or its secondary components. The key 2000-01 project goal was to equip an ADOT snowplow with a roadway-based driver-assistance system for long-term tests in Arizona.

At that point, the Caltrans program did not have the staff resources to assemble another ASP

system, or to provide support for operations outside of California. Also, the current Caltrans RoadView snowplow was very much a developmental prototype and many key ASP components were not packaged systems, but were unique or even hand-built.

Other options were needed, so in late 2000, ATRC and ADOT's Flagstaff District procured a 3M Lane Awareness System (LAS) and five miles of 3M's magnetic striping tape. This tape was installed between layers of asphalt pavement in a reconstruction project on US 89 northeast of Flagstaff at Sunset Crater, as a test site for the new ADOT-3M advanced snowplow. This new ASP was also equipped with a collision warning radar system, for comparison with RoadView.

ADOT continued its long-term evaluation program with Caltrans in Phase Two, with a new goal of comparing both guidance systems in similar weather and road conditions. Both the Caltrans and the 3M concepts were developed as low-visibility, low-speed driver-assistance systems. Northern Arizona University joined ATRC's project team in 2000 to provide neutral Phase Two evaluations, while 3M also funded a separate study of their system in Arizona by the University of Iowa.

Winter 2001-02: Phase Two(b) Research

This Phase Two(b) project report addresses 2001-02, the second and final winter season of the ADOT side-by-side evaluation program for snowplow lane guidance systems. Testing during the previous winter had been seriously compromised by a combination of technical issues for both of the advanced snowplow systems, so that only limited results had been achieved.

The research efforts for this fourth year of ADOT's IV research program were focused on a more thorough and complete evaluation of the two roadway-based, near-zero-visibility ASP systems. The ATRC's fundamental goal was to determine with confidence the key factors for successful implementation of these two ASP lane guidance systems for rural states such as

Arizona, and to determine the overall state of development, effectiveness, flexibility, and reliability of each.

Winter 2001-02: Research Plan

With two test sites on either side of the San Francisco Peaks, and with all systems fully functional, the project's ambitious back-to-back ASP evaluation plan could finally be implemented for 2001-02. ATRC developed a workplan to test the Caltrans and 3M systems side-by-side for a second season.

The Arizona plan was patterned on the Caltrans evaluation program, as carried out each winter by their site team of technical and human factors specialists. Caltrans used driver surveys and interviews to assess perceptions of the system and its components, after limited instruction and test runs at the roadway magnet site. The Caltrans evaluation team also planned to use on-board data recording, as well as project staff ride-alongs during any major winter storm operations.

The Arizona evaluation emphasis differed from the RoadView test program in California, which focused on a few key drivers assigned to the ASP on I-80 at Donner Summit. The ATRC's goal was to provide information on advanced snowplow concepts to the regional maintenance forces. ADOT Team Leader drivers were assigned to both project snowplows each winter, to conduct introductory training for other operators from the northern Arizona districts. This plan produced a large number of evaluations from a diverse pool of ADOT drivers, but only the designated Team Leader operators gained extensive experience with either ASP snowplow.

The most challenging aspect of ADOT's operator training and evaluation plan was the back-to-back approach to bring in drivers from distant maintenance yards for training on both snowplows in a single day. This project workplan was feasible because the Caltrans magnet site and the 3M tape site were only about 30 miles apart, or roughly a 45-minute drive through Flagstaff.

Winter 2001-02: Training & Evaluation

The two advanced snowplows were both fully functional for the 2001-02 winter season, as the previous year's problems were resolved. As a result, the training program was a success. For the Caltrans plow, with their full project team on hand, a total of 27 ADOT snowplow operators were introduced to the RoadView ASP system. In comparison, 18 of these operators were also trained on the 3M LAS system at the US 89 test site, in most cases on the same day.

Local operational constraints were a factor in training on the ADOT-3M snowplow. Caltrans had staff at the site to support ADOT's Team Leader drivers, and the RoadView ASP initially was dedicated to training. On the ADOT-3M side, the only trainers available were the local Team Leaders, by turns. Also, this plow was sometimes called out for maintenance activities on the highway. Due to these conflicts, a few drivers were trained on this ASP at other times.

The focus was a side-by-side evaluation of two different ASP systems with similar concepts and goals. Driver training on one system in the morning and on another the same afternoon produced informed preference rankings and comparative comments in debriefing surveys and interviews. This approach was valid, although many operators had only brief exposure to each system.

After an initial briefing, drivers made one or two runs in 30 to 45 minutes at each test site with an ADOT Team Leader or with Caltrans project staff. This was sufficient time for the experienced ADOT drivers to develop their responses to the "preference" questions on the survey, and to also provide numerous comments and suggestions for improvements to both ASP systems.

Another key activity was the Caltrans RoadView impaired-vision test. As it became apparent that no major storms would occur during the Arizona site activities, the Caltrans team developed a "no-snow" ride-along evaluation plan for night performance testing on US 180. The late evening and nighttime effort, during the last

three days of the evaluation program, developed significant data on driver adaptation to the RoadView guidance system. The data included radar performance, progression of steering and tracking accuracy, and mean speed for multiple runs over the test course with three ADOT plow operators of different experience levels.

Winter 2001-02: Operational Activities

The project's Phase Two(b) winter was a disappointment with regard to operations. The two project snowplows were fully operational, but it was an unusually mild and dry winter, with less than half the normal snowfall for Flagstaff. In fact, no measurable snow fell during the entire five weeks that the Caltrans ASP was in Arizona. The ADOT-3M plow was used in a series of moderate storms early in the season, when it was operated successfully on at least eleven dates between November and March when snow fell in recordable quantities.

Winter 2001-02: Results

The Phase Two(b) winter was the second full season of operations and training for the dedicated ADOT-3M snowplow, fulfilling the fundamental mandate for the research project. This was also the fourth winter of the Caltrans RoadView snowplow partnership activities, demonstrating the long-term potential for the concept as it became more reliable and robust for each winter season.

For Caltrans, the training results were positive, with significant data developed from both the on-board instrumentation and from the operator feedback of the surveys, interviews and ride-alongs. However, operational deployment in storms was impossible, due to the mild weather during the limited Arizona test period.

For the ADOT-3M snowplow, the testing and operations with the tape-based guidance system were spread over the full winter. Operational results were positive, despite the limited number of major storms that occurred. The drivers had no significant problems with the on-board components through the winter. Their level of

confidence was good for both the 3M lane guidance and the warning radar systems.

ADOT ASP Project Results: 1997-2002

The most basic result of four winters of ADOT's snowplow research is the confirmation that both Caltrans and 3M have successfully developed effective and reliable advanced snowplow lane guidance systems that, if deployed, would provide significant benefits to Arizona for winter maintenance operations in extreme storm conditions.

For this research program to date, however, the variable weather, and the equipment and roadway problems, have repeatedly constrained a clear identification of potential benefits. At the present time, commercial ASP system sourcing and cost issues preclude any clear determination of the relative value of each of these infrastructure-based guidance systems for a wider deployment.

Future Program Direction

After four winters it was clear to the project sponsors that the cost of either lane guidance system was prohibitive for ADOT. In early 2002, the project objectives were further revised. The new focus for 2002-03 will be on driver warning systems to plow more safely when blowing snow impairs vision, rather than to forge ahead in near-zero-visibility, white-out storm conditions.

The Year Five research will evaluate commercial on-board warning systems in limited-visibility storm conditions. Collision warning radar systems (CWS) and passive-infrared (IR) night vision cameras have been selected for field-testing. The number of on-board units and test areas across northern Arizona will also be increased, allowing ADOT's Holbrook and Kingman Districts to participate in the research program on an equal basis with the Flagstaff District for the first time.

The full project report: *Arizona Intelligent Vehicle Research Program – Phase Two(b): 2001-2002* by Stephen R. Owen, PE, of the Arizona Transportation Research Center (Arizona Department of Transportation, report number FHWA-AZ-03-473(3), published September 2003) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 S. 17 Ave., MD 075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies through ADOT's Engineering Records Section.